

SRT Evaluation of AIRS Version-6.02 Products

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AIRS Science Team Meeting

April 26, 2012
Pasadena, CA



Major Advances in Version-6 Compared to Version-5

- Improved methodology to determine skin temperature (T_s) and spectral emissivity (ϵ_v)
- Use of Neural-net start-up state (Bill Blackwell)
 - Allows for accurate retrievals under more difficult cloud conditions
- Improvements which decrease the spurious negative Version-5 trend in tropospheric temperatures (Eric Maddy)
 - Reducing spurious $T(p)$ trends reduces other spurious trends as well
- Improved QC methodology
 - Separate QC thresholds for Data Assimilation (QC=0) and Climate applications (QC=0,1)
- Channel-by-channel clear-column radiance $\hat{R}_i$ QC flags
- Improved cloud parameter retrieval algorithm (Evan Manning, Van Dang, John Blaisdell)
- Improved OLR RTA (Gyula Molnar)



Evaluation Methodology

Comparisons of V6.02, V6.02 AO, and V5.0

Products to be evaluated

T_s , ϵ_v , $T(p)$, $q(p)$, OLR, OLR_{CLR} , α , $\hat{R}_i$

Two types of evaluation

- 7 focus days compared to ECMWF truth

T_s , ϵ_v , $T(p)$, $q(p)$

RMS differences, yields, biases, trends

$\hat{R}_i$ channel by channel QC'd values for V6.02 and V6.02 AO
yields, accuracy

- Monthly means for 4 different months, 3 different years

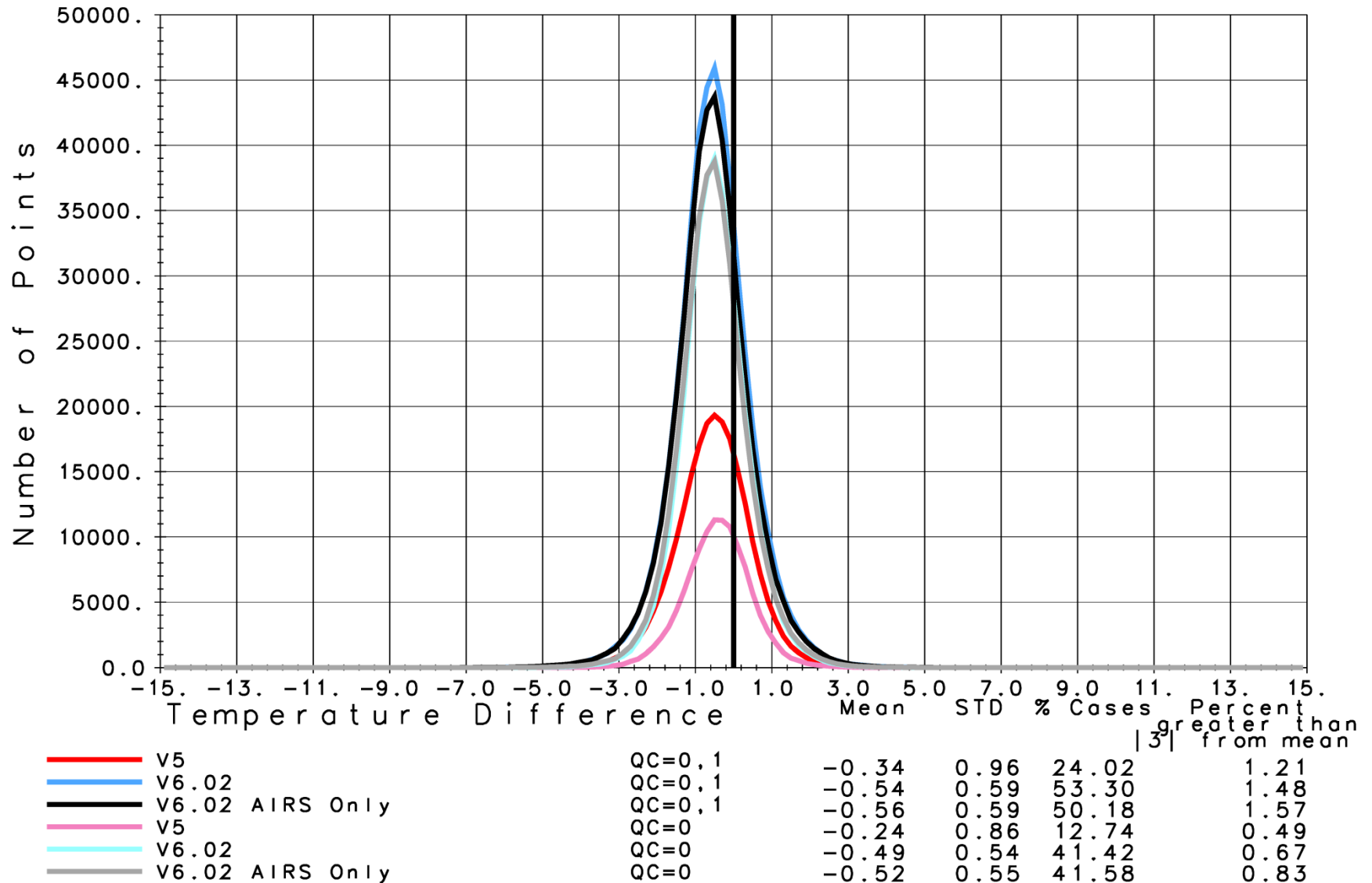
V6.02(actually V5.9.12) compared to V5.0

$T(p)$, $q(p)$, α , OLR, OLR_{CLR}

trends, trend differences

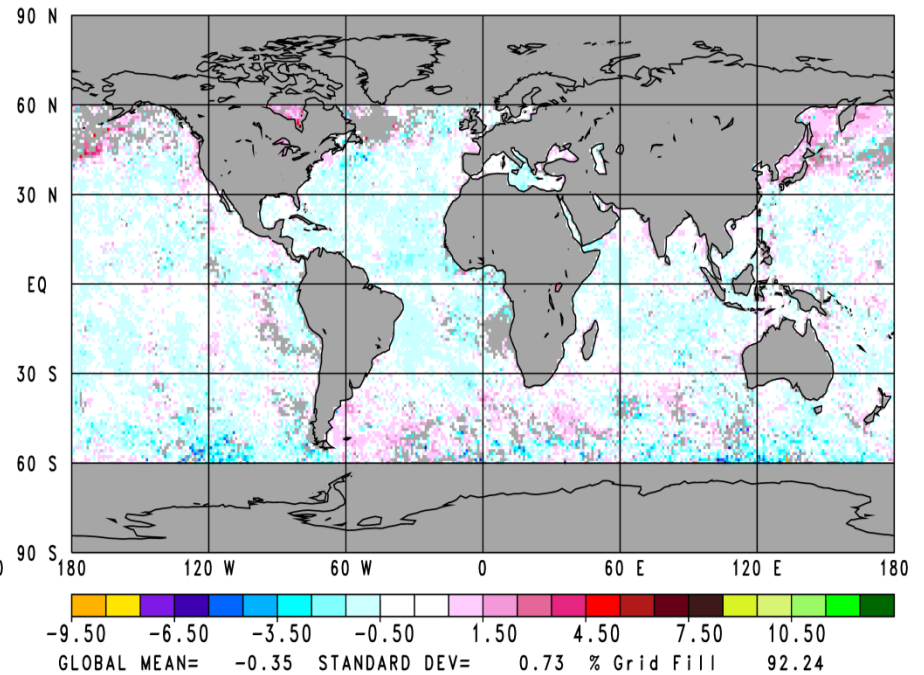
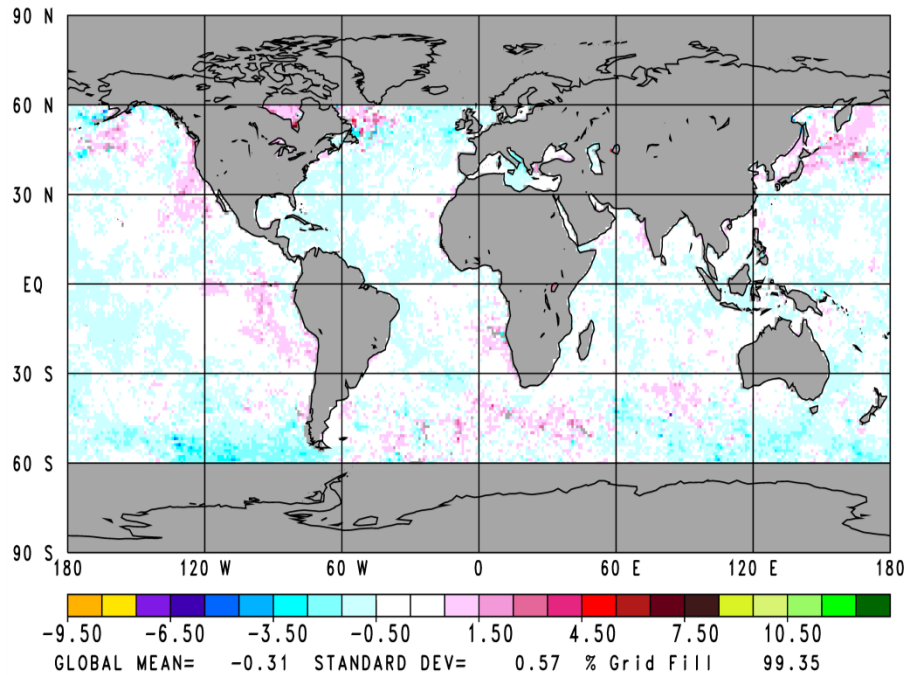


Surface Skin Temperature Difference 7-Day Daytime and Nighttime combined 50 N to 50 S Non-Frozen Ocean

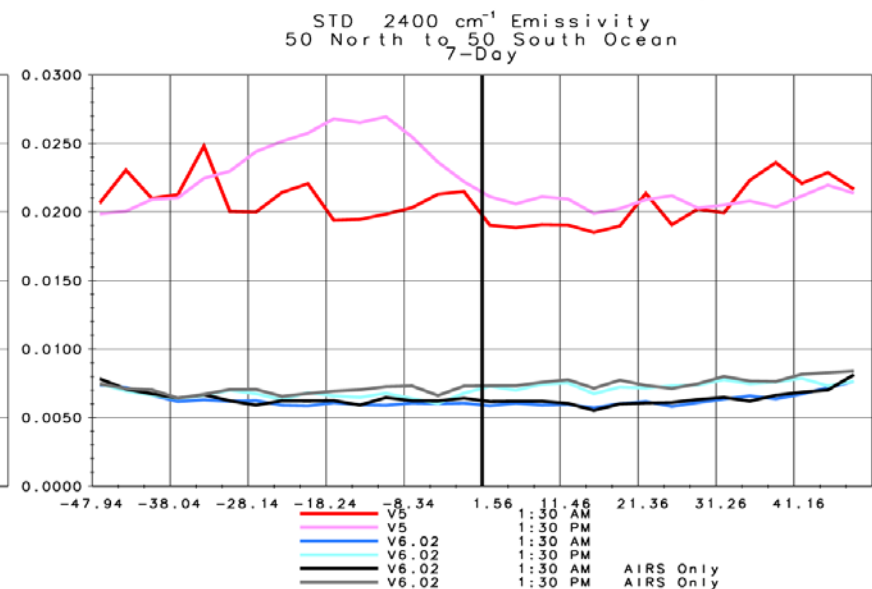
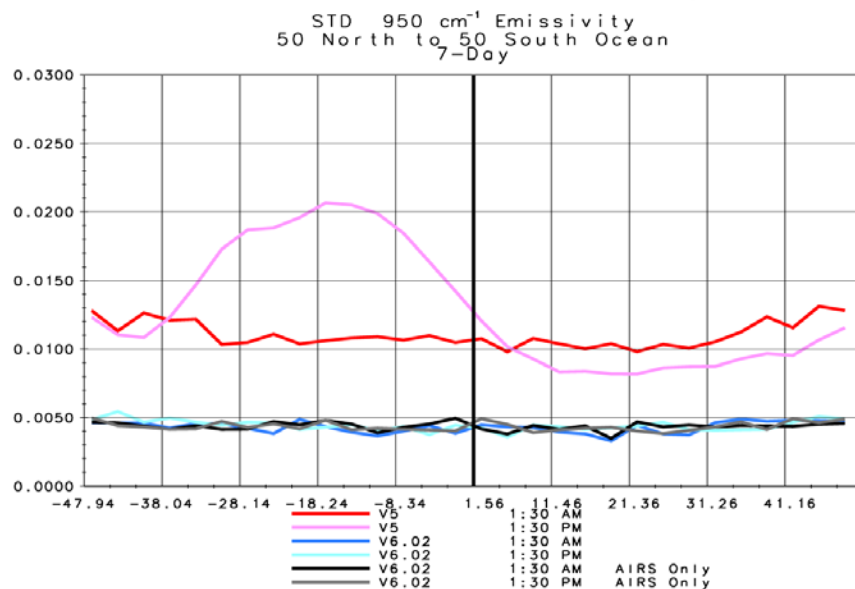
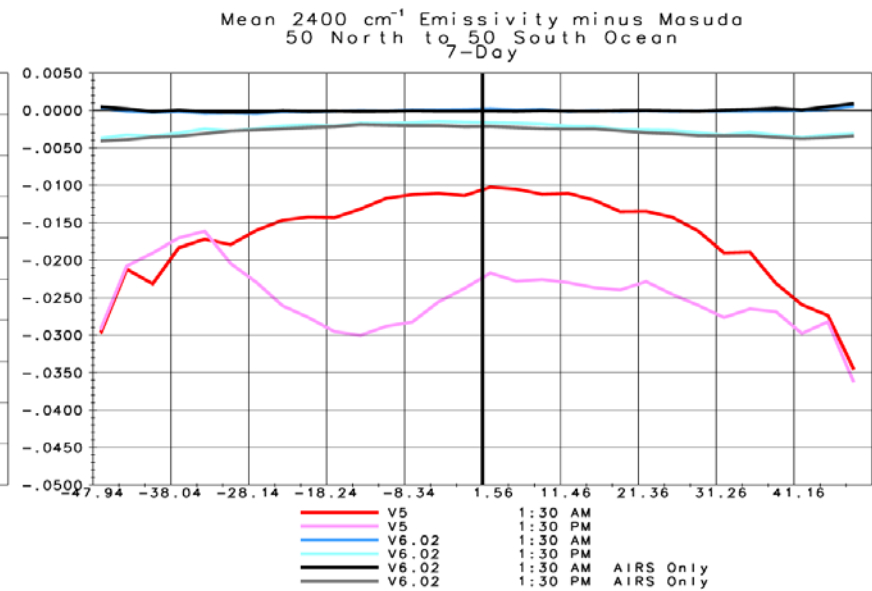
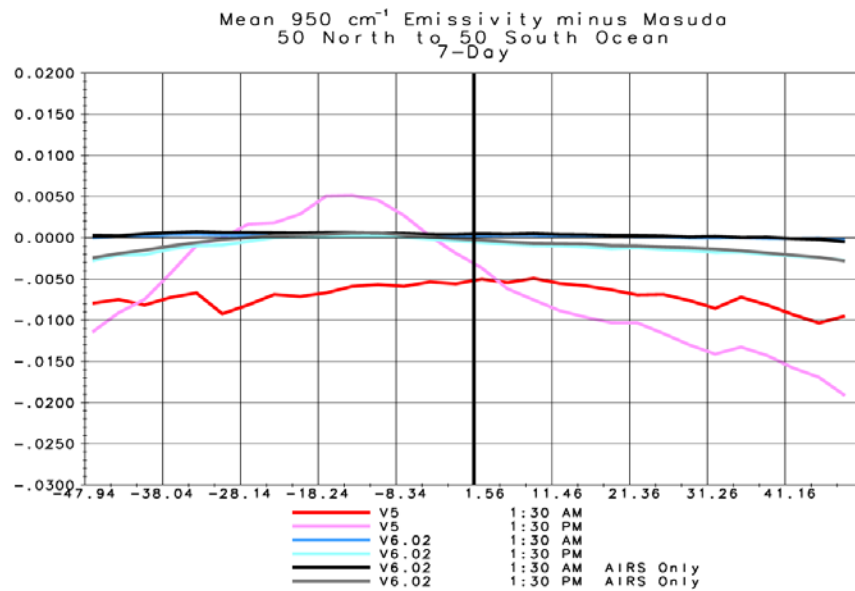


7-Day Surface Skin Temperature (K) Non-Frozen Ocean Retrieved minus ECMWF AM/PM Average

Version-6.02 Version-5

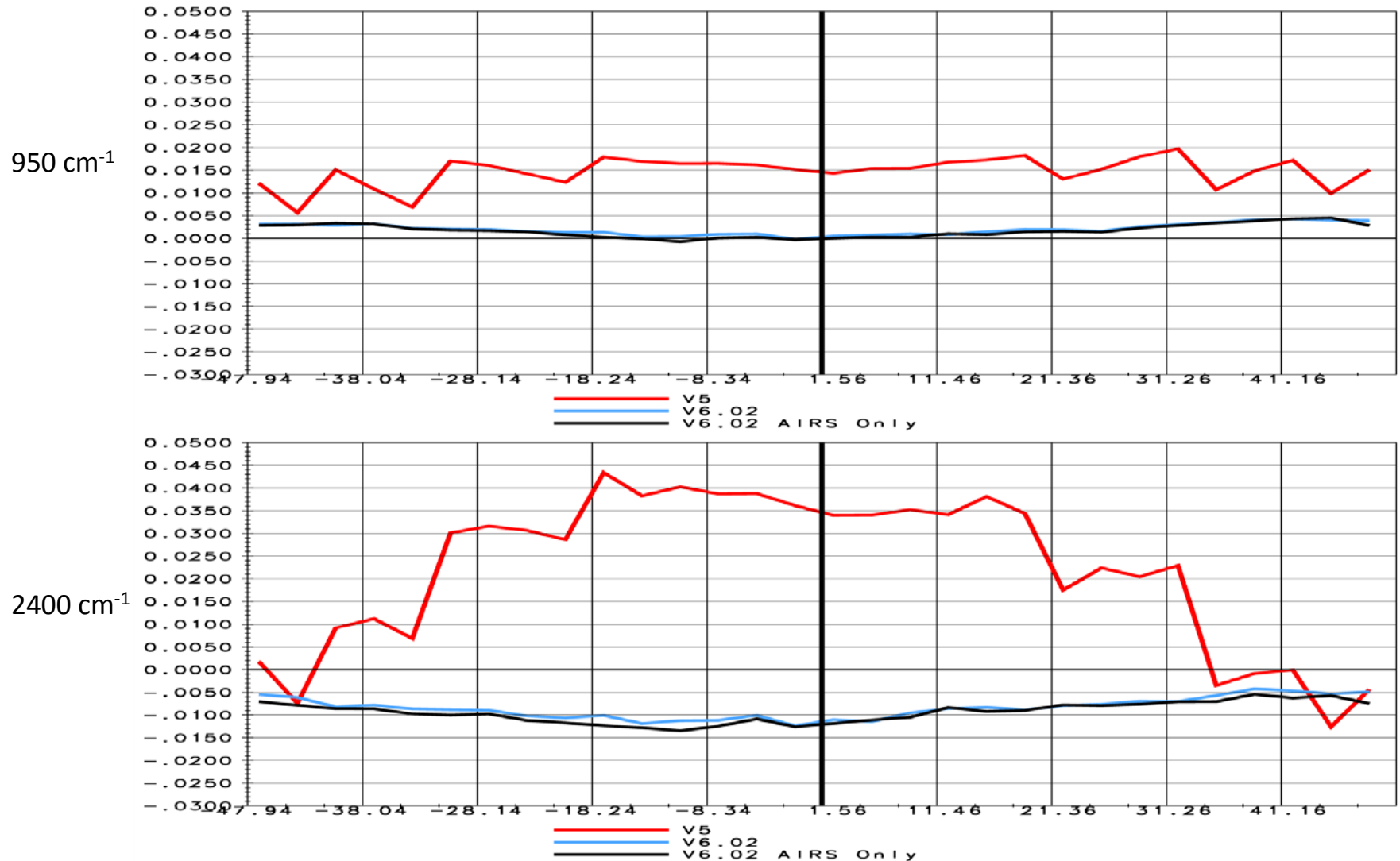


Seven day Version-6 Level-3 SST product has much better spatial coverage and accuracy compared to Version-5 Level-3 SST product.



AIRS Version-6 ocean spectral emissivities as a function of satellite zenith angle are much closer to Masuda than Version-5 and are more stable.

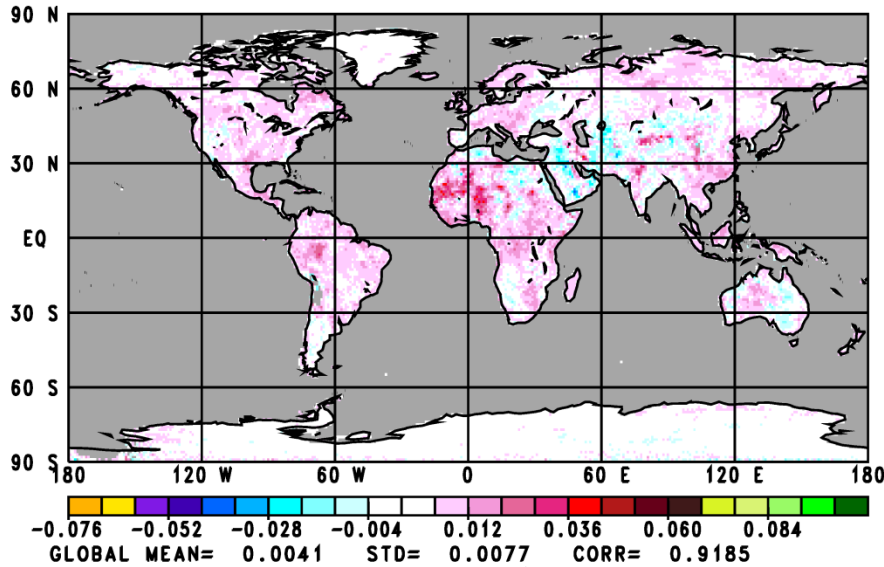
Mean AM minus PM Emissivity 7-Day Average
50° North to 50° South Land



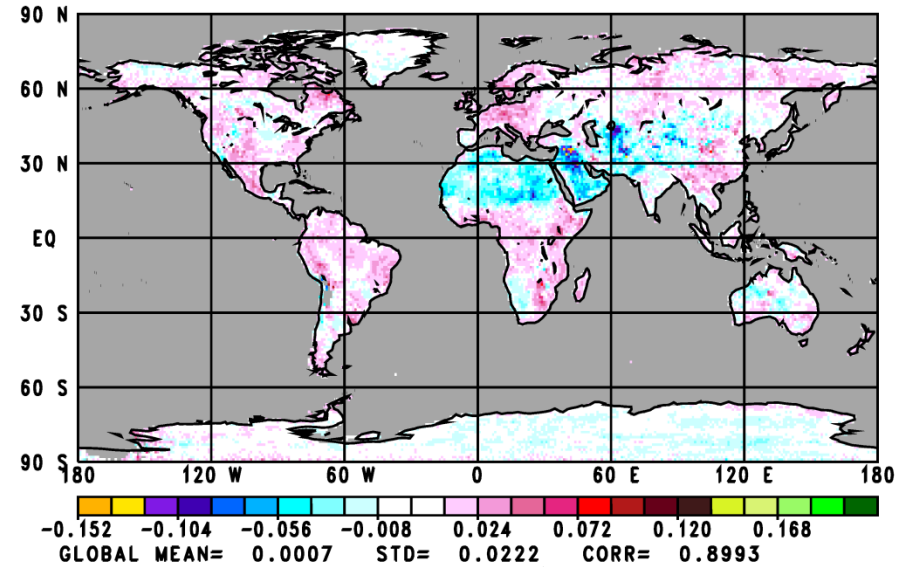
AIRS Version-6 day/night differences of land surface emissivity as a function of zenith angle and much smaller than Version-5.

7-Day AIRS IR Emissivity 1:30 AM minus 1:30 PM

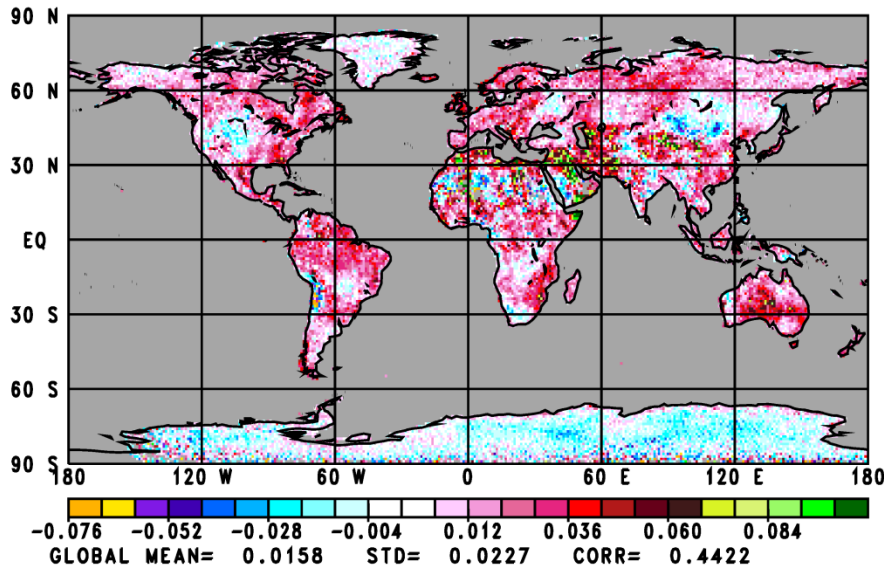
950 cm^{-1}
Version-6.02



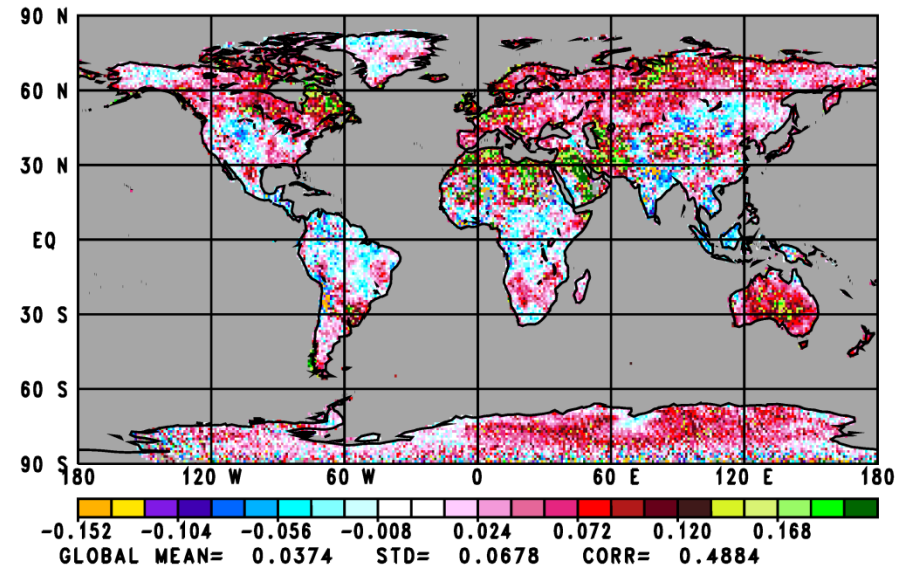
2400 cm^{-1}
Version-6.02



950 cm^{-1}
Version-5



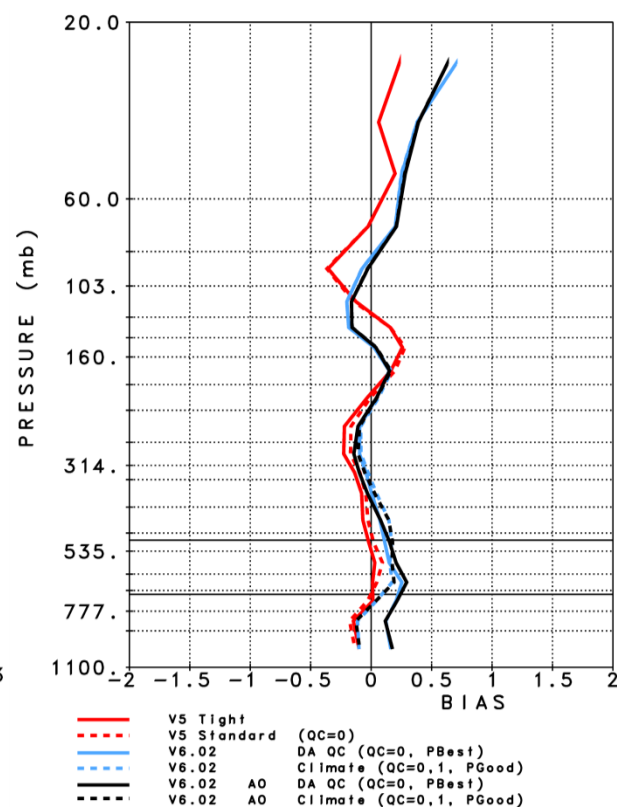
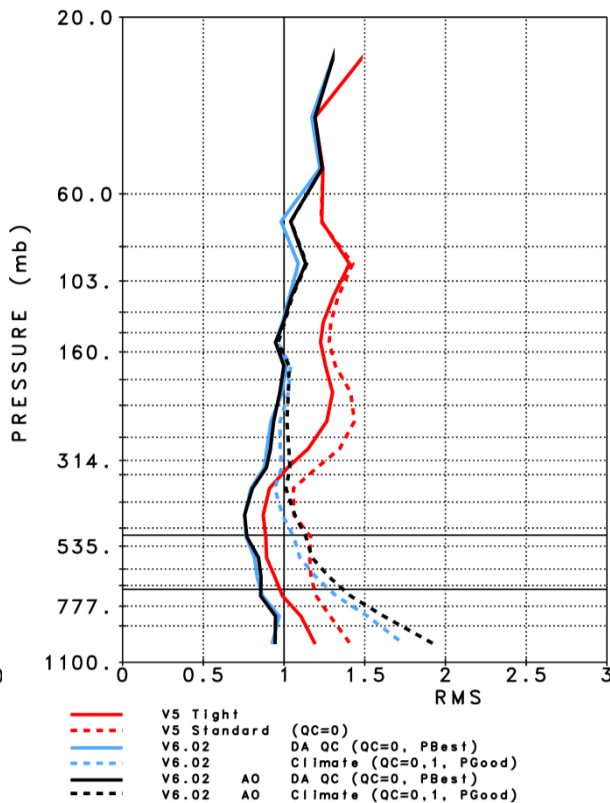
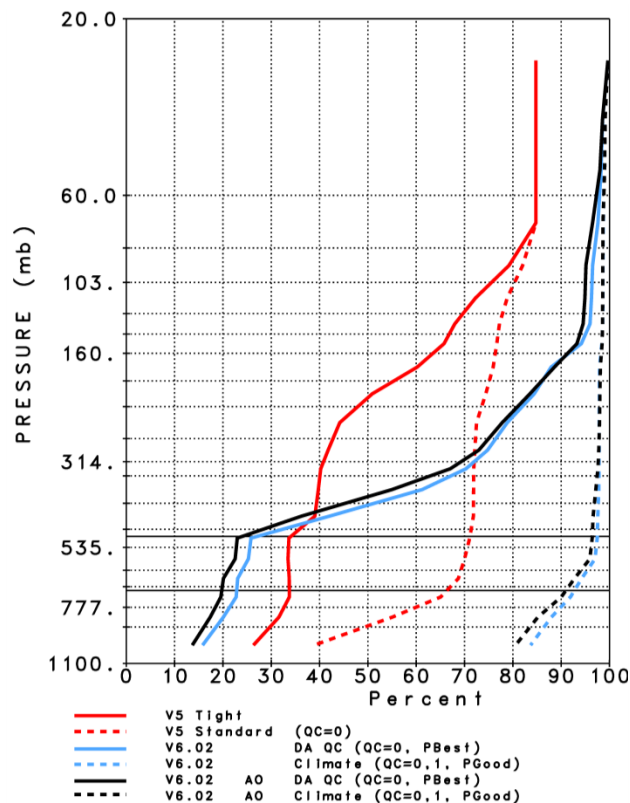
2400 cm^{-1}
Version-5



Global Temperature 7-Day Statistics use their own QC

Percent of All Cases Accepted Layer Mean RMS ($^{\circ}\text{K}$) Layer Mean BIAS ($^{\circ}\text{K}$)

Accepted Differences from ECMWF Differences from ECMWF



Version-6 T(p) retrievals with DA QC have RMS errors $\leq 1\text{K}$ throughout troposphere
 Version-6 T(p) retrievals with Climate QC have much greater yield than Version-5 with small biases
 Differences between Version-6.02 and Version-6.02 AO are small

Global Water Vapor 7-Day Statistics use their own QC

1 Km Layer Mean

1 Km Layer Mean

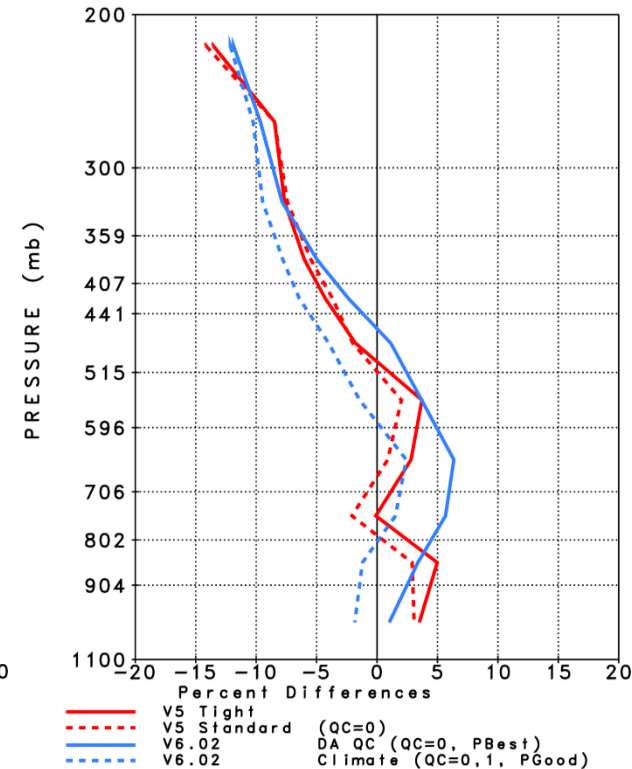
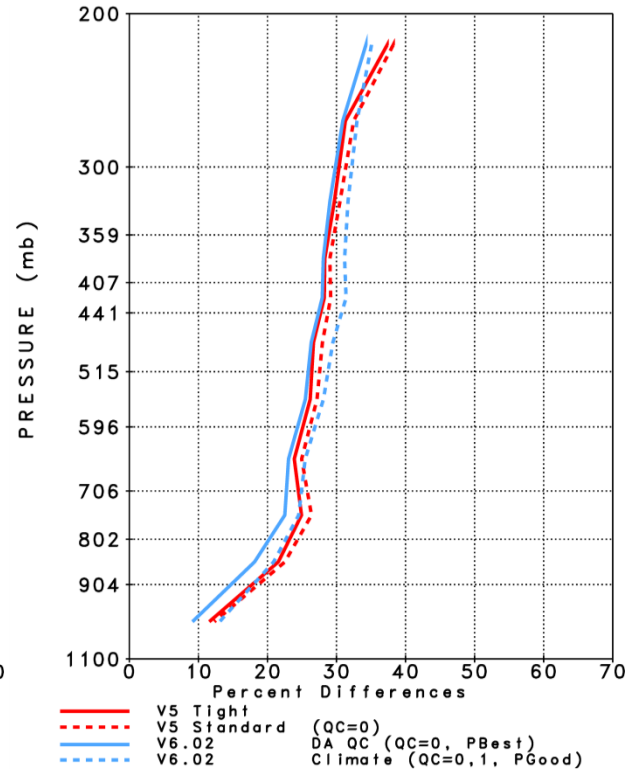
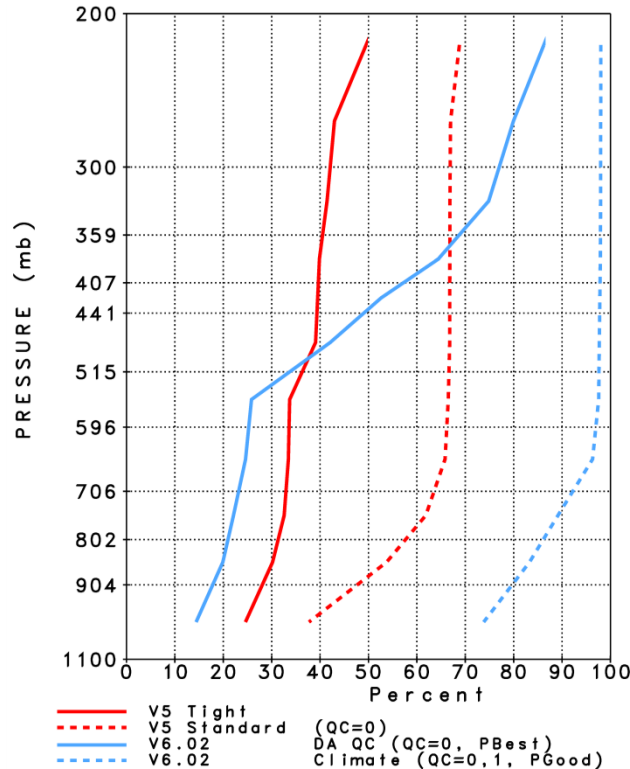
Precipitable Water RMS

Precipitable Water Bias

% Differences from ECMWF

% Differences from ECMWF

Percent Yield



Version-6 q(p) retrievals with DA QC are improved over Version-5 in lower troposphere

This is a result of improved T_s , ϵ_v

Version-6 q(p) retrievals with Climate QC are unbiased and have high accuracy with almost complete spatial coverage

Global Water Vapor 7-Day Statistics use their own QC

1 Km Layer Mean

1 Km Layer Mean

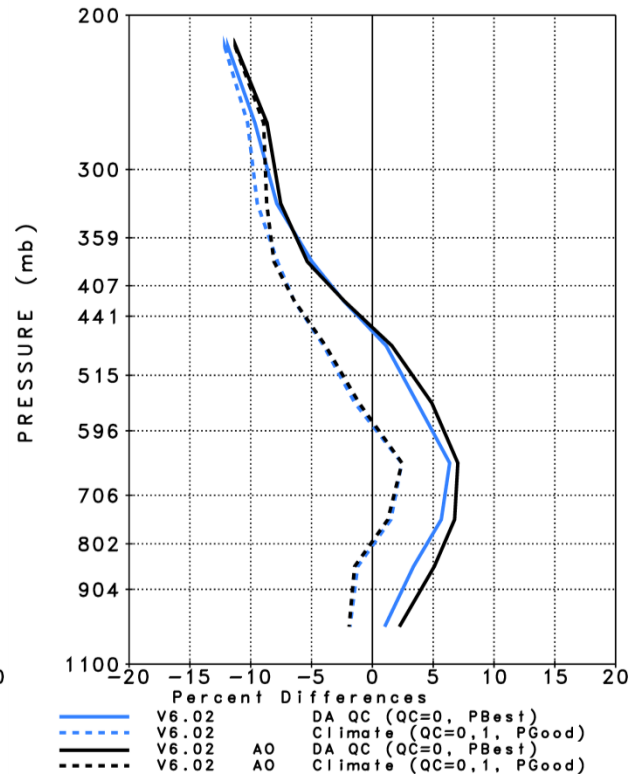
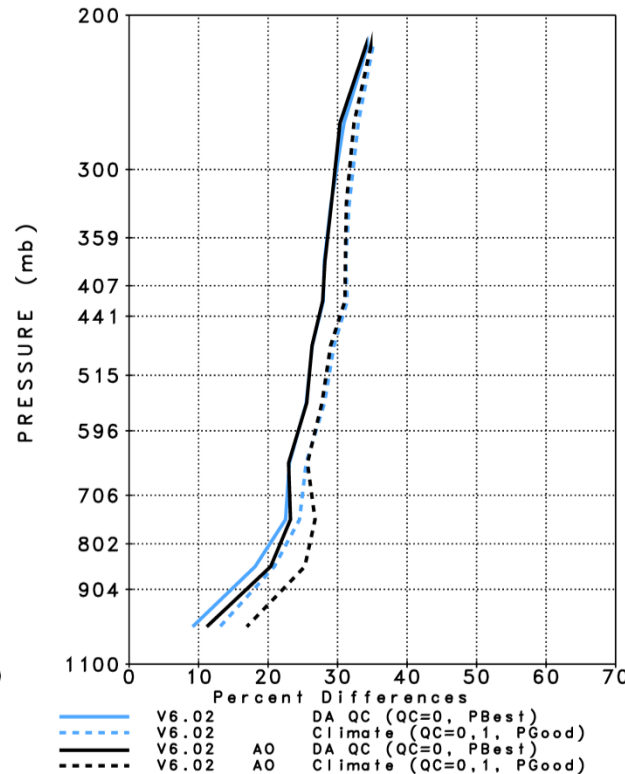
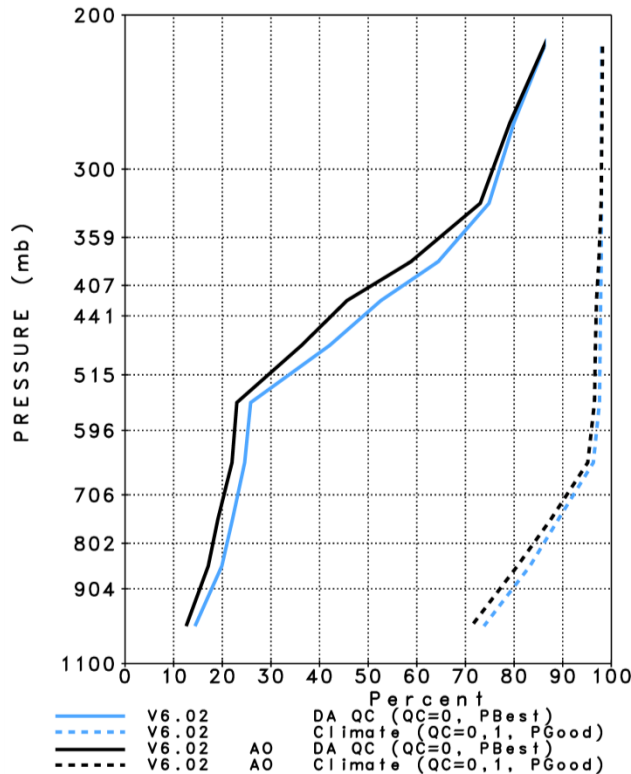
Precipitable Water RMS

Precipitable Water Bias

% Differences from ECMWF

% Differences from ECMWF

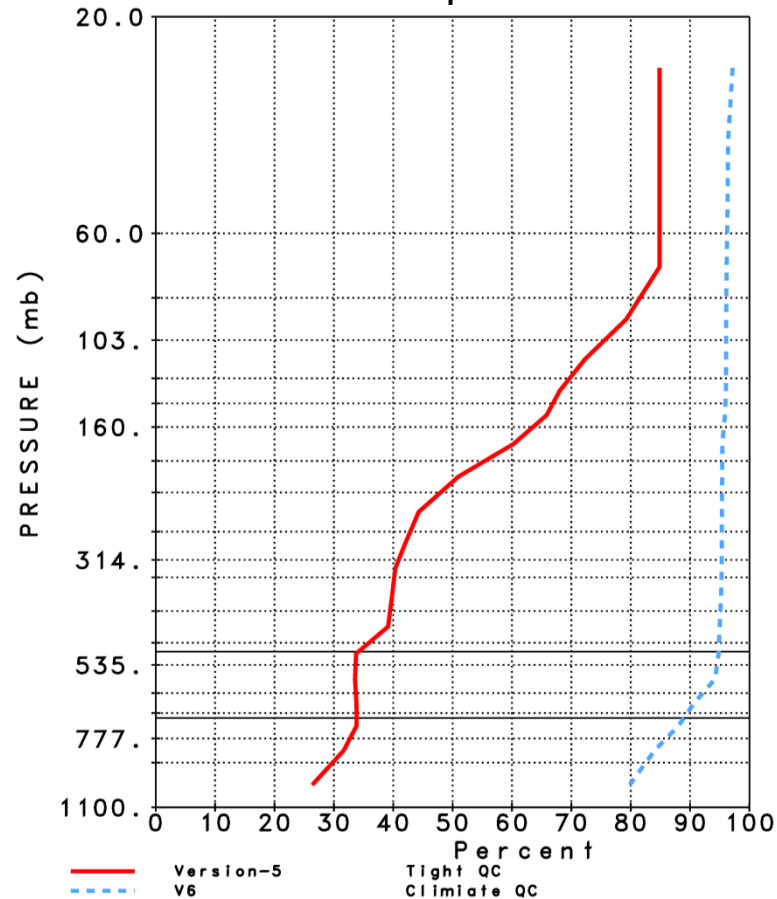
Percent Yield



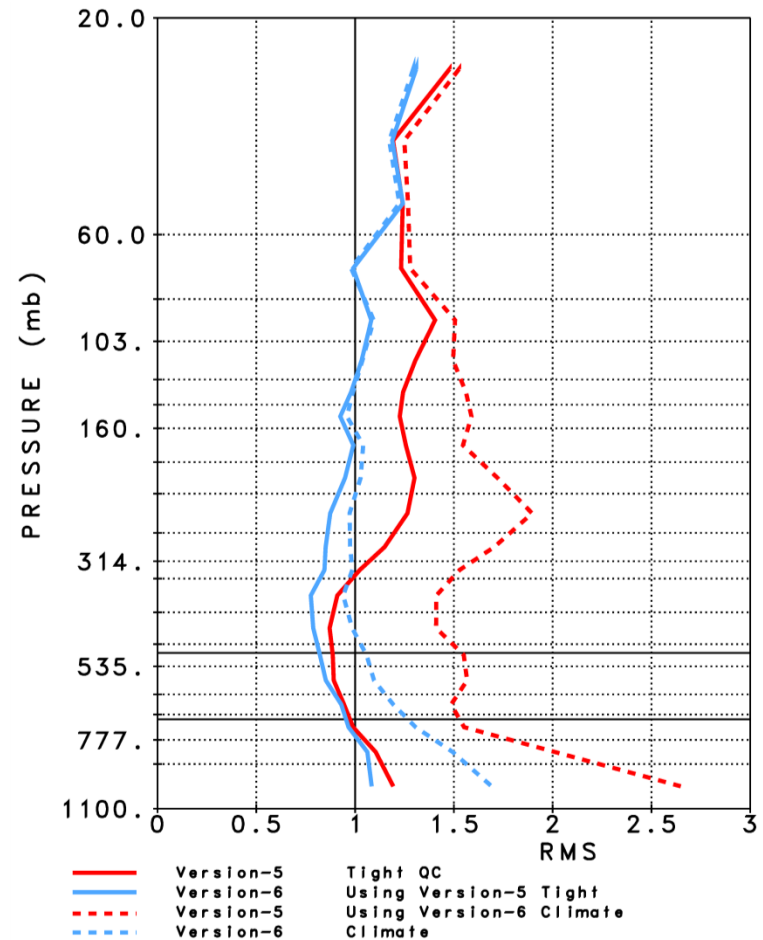
Version-6 AO water vapor retrievals are slightly poorer than Version-6, but still of high accuracy.

Global Temperature 7-Day Two Common Ensembles

Percent of All Cases
Accepted



Layer Mean RMS ($^{\circ}$ K)
Differences from ECMWF



7-Day Mean Statistics Tropospheric Temperature Metric (TTM) and Boundary Layer Metric (BLM)

Cases in Common Using the Version-5 Tight Ensemble

	<u>Global</u>		<u>Land $\pm 50^\circ$</u>		<u>Ocean $\pm 50^\circ$</u>		<u>Poleward of 50°N</u>		<u>Poleward of 50°S</u>	
	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>
Version-5	1.10	1.29	1.19	1.71	1.04	1.13	1.14	1.50	1.31	1.76
Version-6.02	0.92	1.16	0.94	1.49	0.86	0.98	0.96	1.47	1.20	1.69

Cases in Common Using the Version-6.02 Climate Ensemble

	<u>Global</u>		<u>Land $\pm 50^\circ$</u>		<u>Ocean $\pm 50^\circ$</u>		<u>Poleward of 50°N</u>		<u>Poleward of 50°S</u>	
	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>	<u>TTM</u>	<u>BLM</u>
Version-5	1.67	2.57	1.82	2.78	1.65	2.48	1.53	2.39	1.72	2.72
Version-6.02	1.11	1.67	1.06	1.75	1.03	1.34	1.12	1.93	1.32	2.02

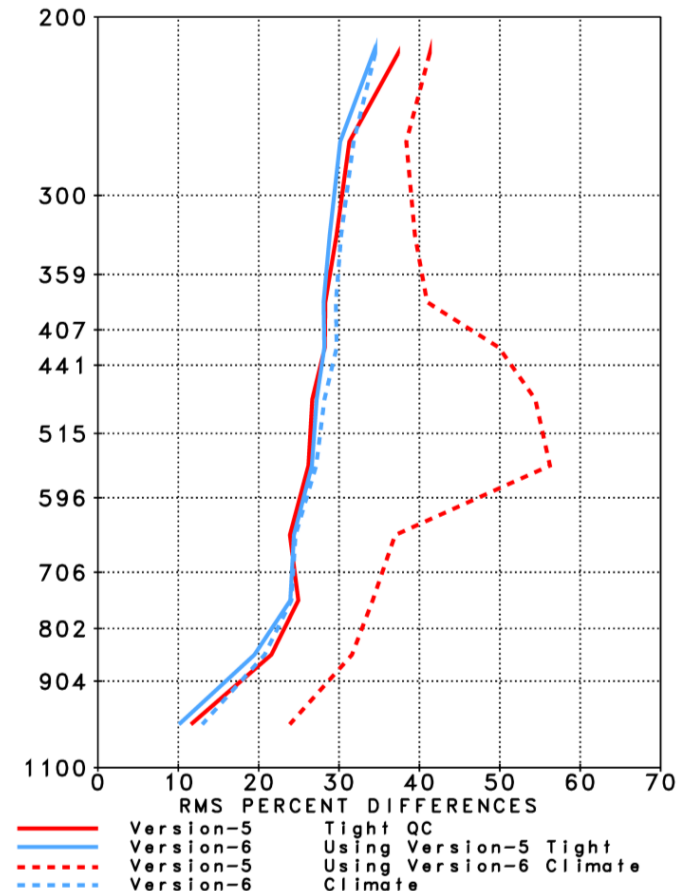
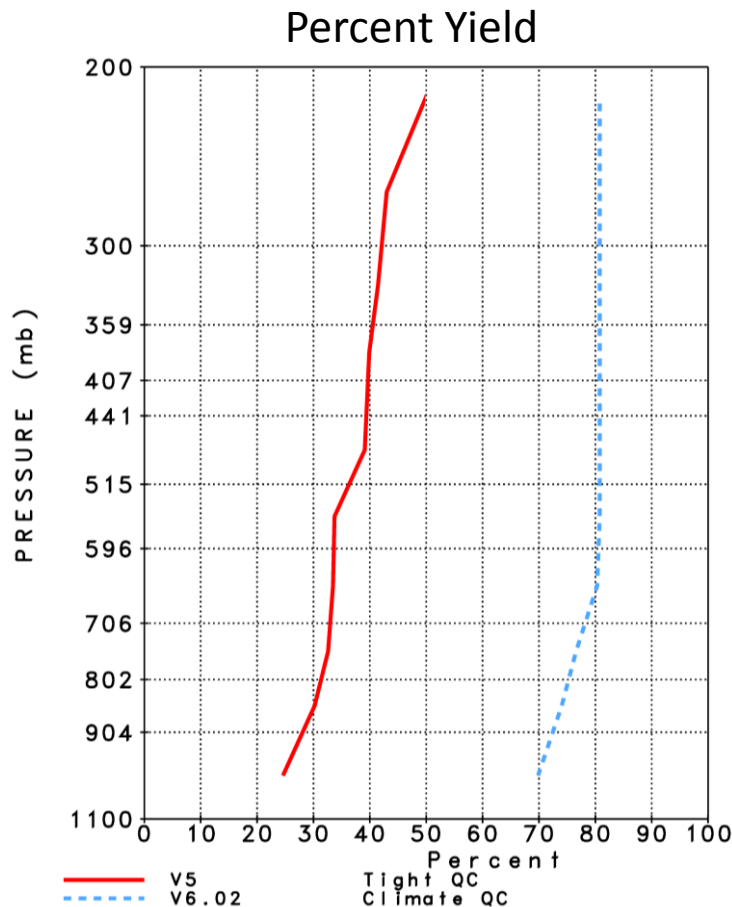
TTM represents the mean RMS T(p) error over all 1km layers from the surface to 100 mb
BLM represents the mean RMS T(p) error over the 6 lowest 0.25km layers from the surface

Global Water Vapor 7-Day Statistics using a Common Ensemble

1 Km Layer Mean

Precipitable Water RMS

% Differences from ECMWF

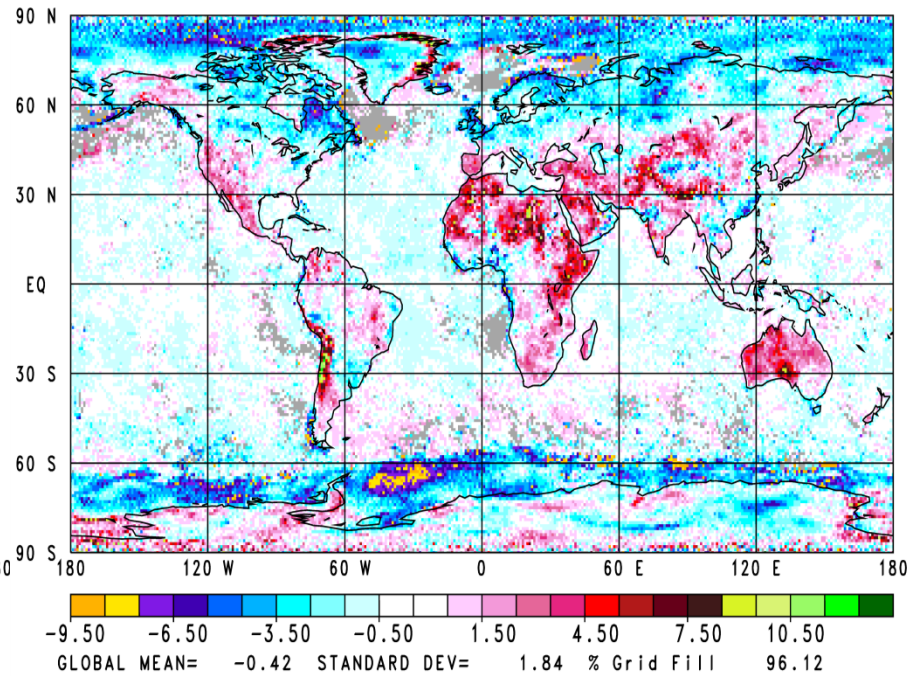
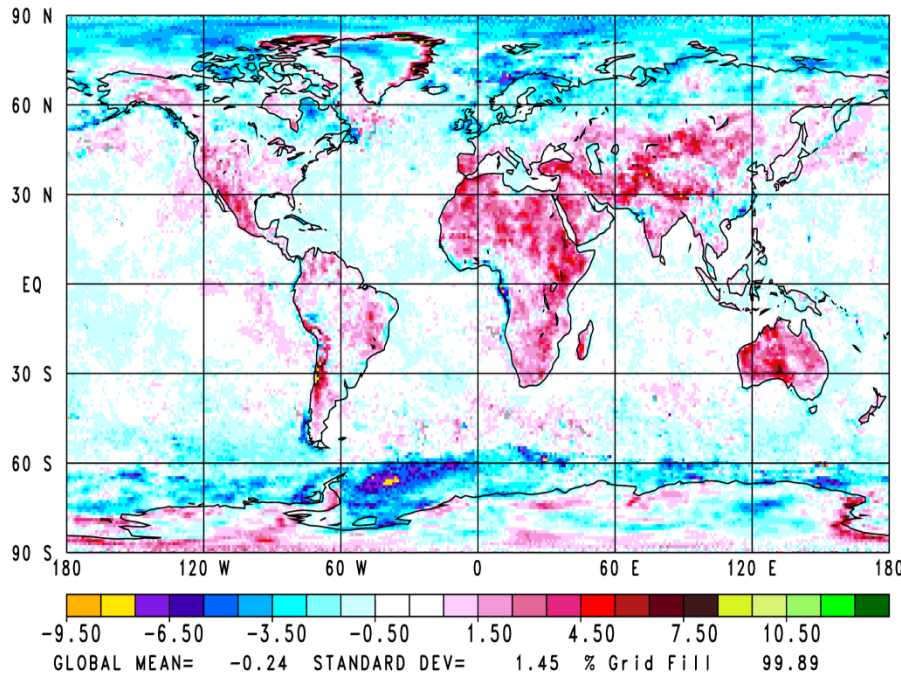


High accuracy of Version-6 water vapor products under most cloud conditions allows for much better level-3 water vapor products.

7-Day Surface Total Precipitable Water (cm) Retrieved minus ECMWF AM/PM Average

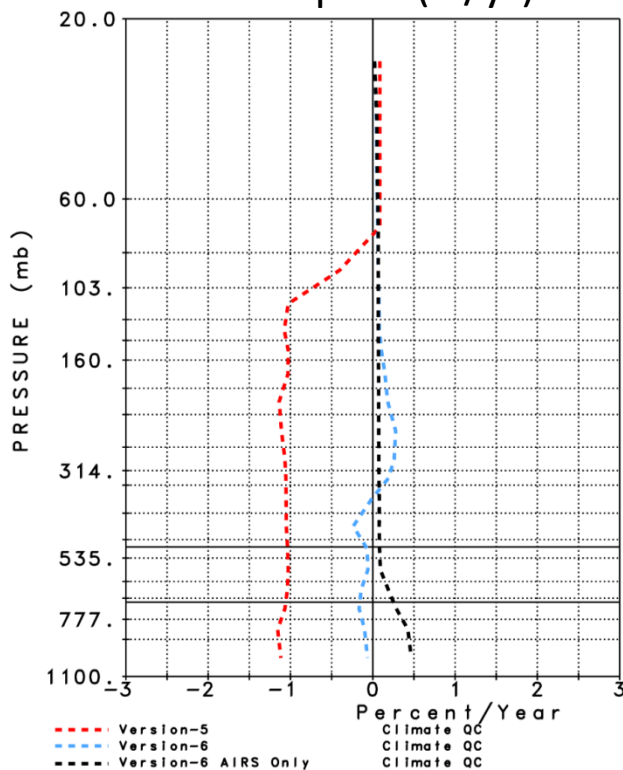
Version-6.02

Version-5

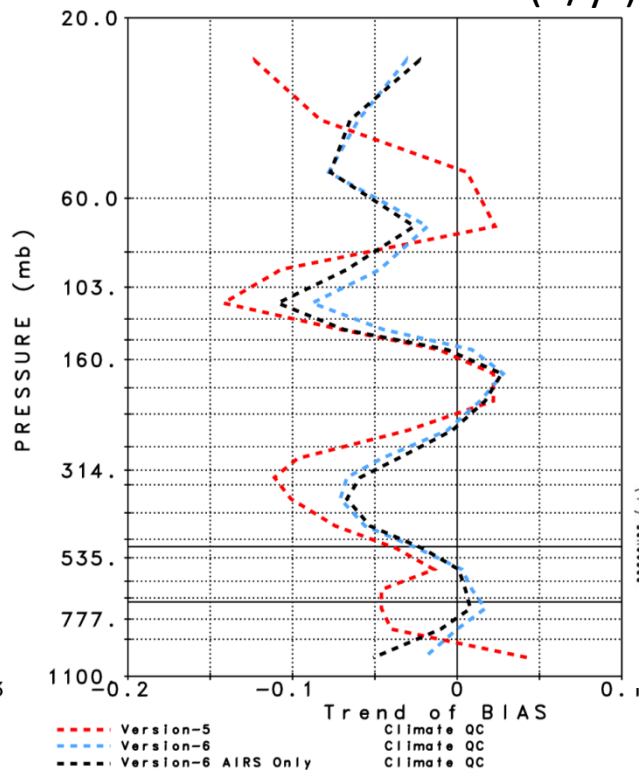


Global Trends 7-Day

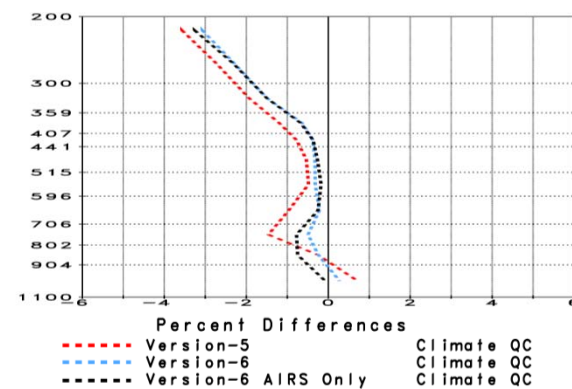
Percent of All Cases Accepted (%/yr)



Layer Mean Temperature BIAS Differences from ECMWF (K/yr)



Layer Mean Water Vapor Bias % Differences from ECMWF (%/yr)



Version-6 has eliminated the negative yield trend found in Version-5

Version-6 negative T(p) and q(p) bias trends are much smaller than Version-5

Negative q(p) bias trends follow those of T(p)

A cold temperature solution (trend) result lowers computed radiance for water vapor channels

The q(p) solution will decrease the retrieved water amount to raise the computed radiances

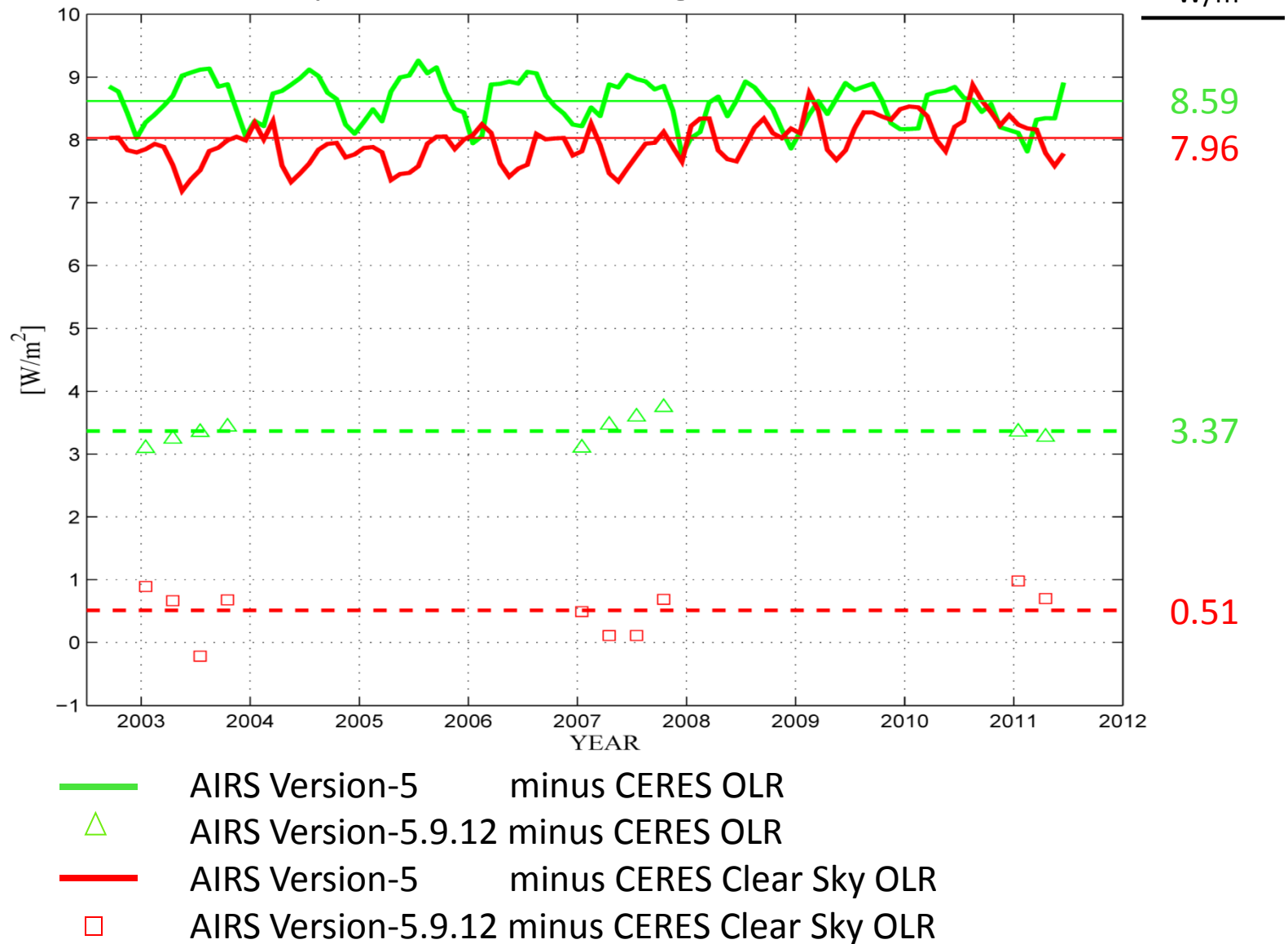
Lowered q(p) (trend) gives too high a computed radiance in window channels – results in increased retrieved cloud fraction (trend)



Global OLR and Clear Sky OLR

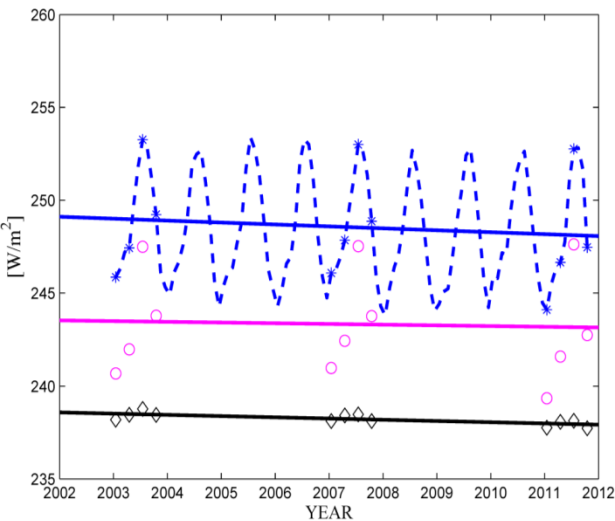
AIRS minus CERES Edition 2.6r EBAF

September 2002 through June 2011

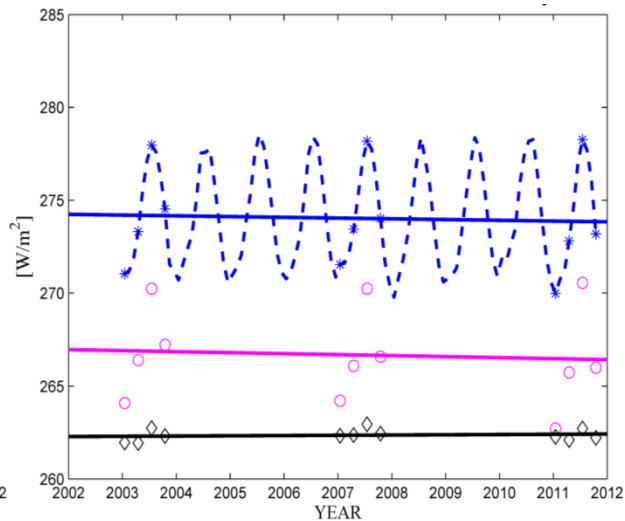


Global Time Series January 2003 through October 2011

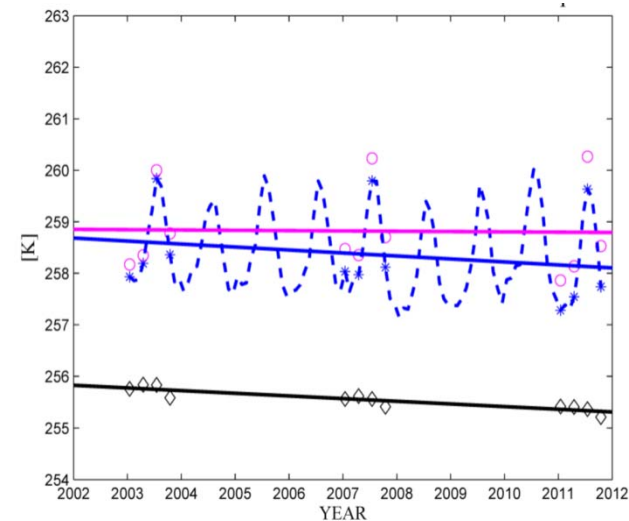
OLR (W/m^2)



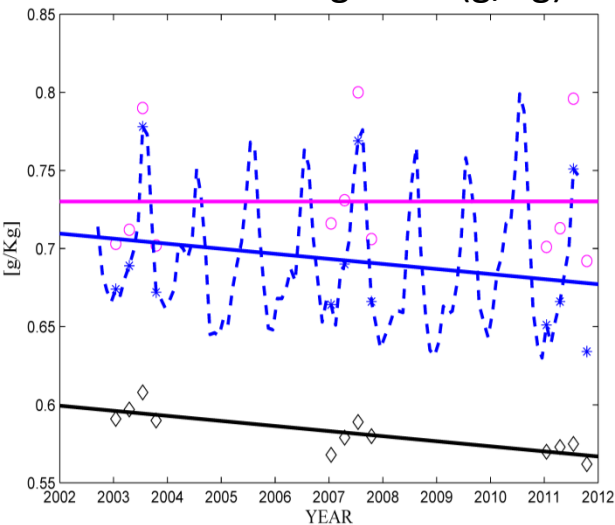
Clear Sky OLR (W/m^2)



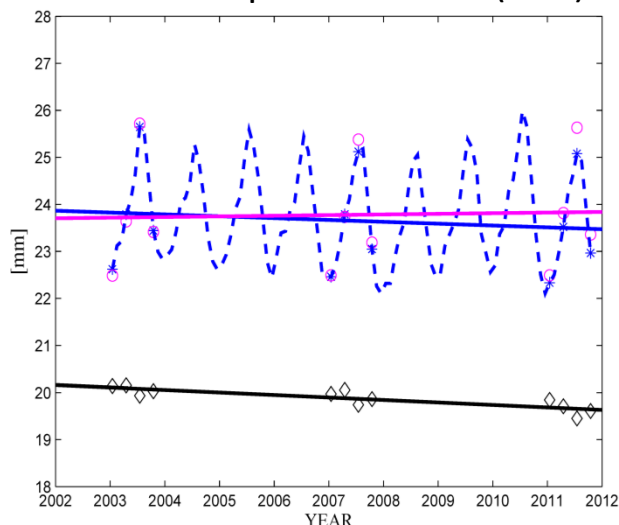
500 mb Temperature (K)



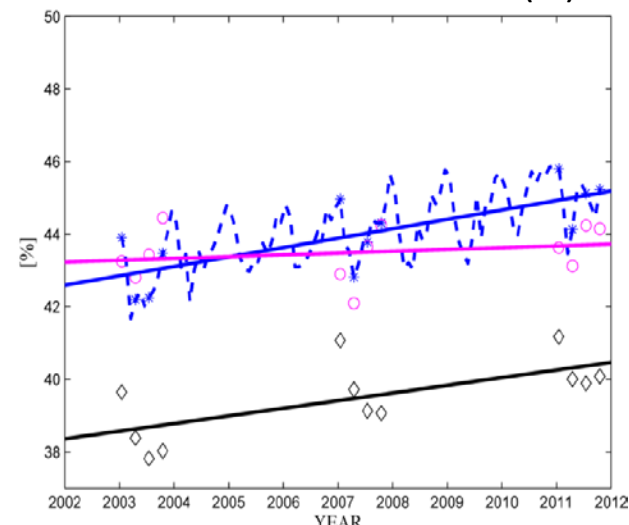
500 mb Mixing Ratio (g/Kg)



Total Precipitable Water (mm)



Effective Cloud Fraction (%)



— AIRS V5 January 2003 through October 2011

○ AIRS V5.9.12 12 Months

— Slope

◇ AIRS V5 minus AIRS v5.9.12

— Slope

* AIRS V5 12 Months



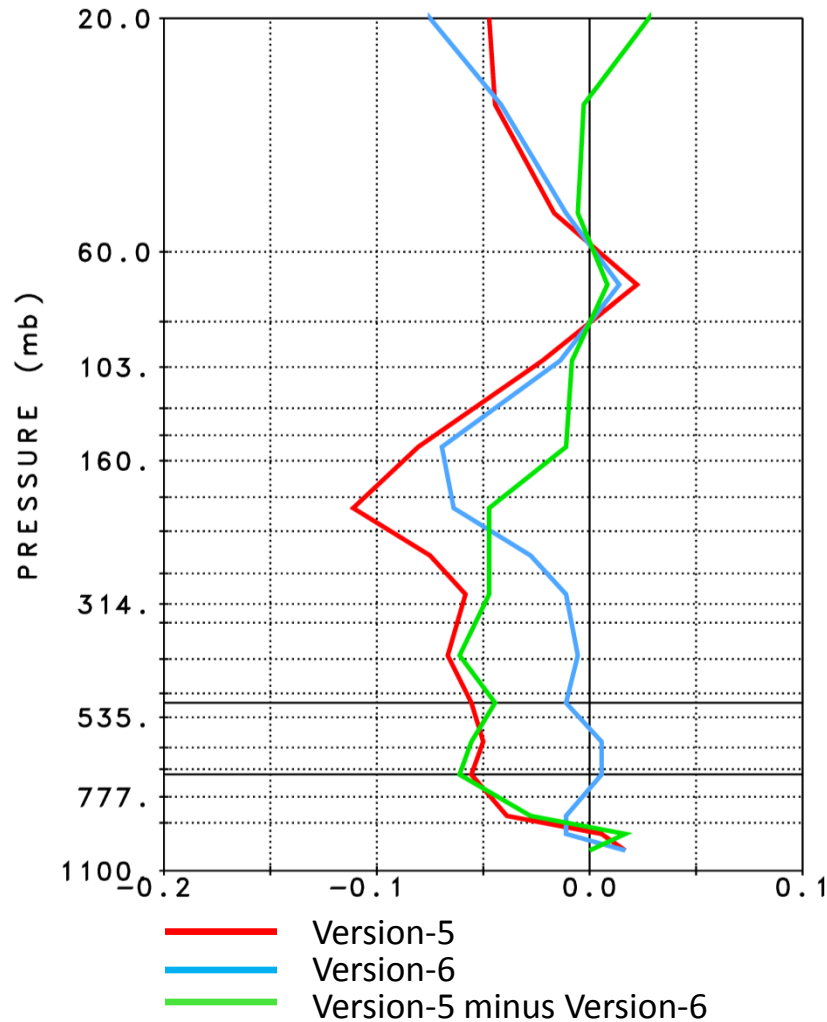
12 Month Global Time Series Slopes (Trends) January 2003 through October 2011

	OLR W/m ² /yr	Clear Sky OLR W/m ² /yr	500 mb Temp K/yr	500 mb Mixing Ratio g/Kg/yr	Total Precipitable Water mm/yr	Cloud Fraction %/yr
* AIRS V5	-0.104	-0.040	-0.058	-0.00325	-0.392	0.260
○ AIRS V5.9.12	-0.038	-0.054	-0.006	0.00001	0.137	0.049
◇ AIRS V5 minus AIRS v5.9.12	-0.066	0.014	-0.052	-0.00326	-0.529	0.211

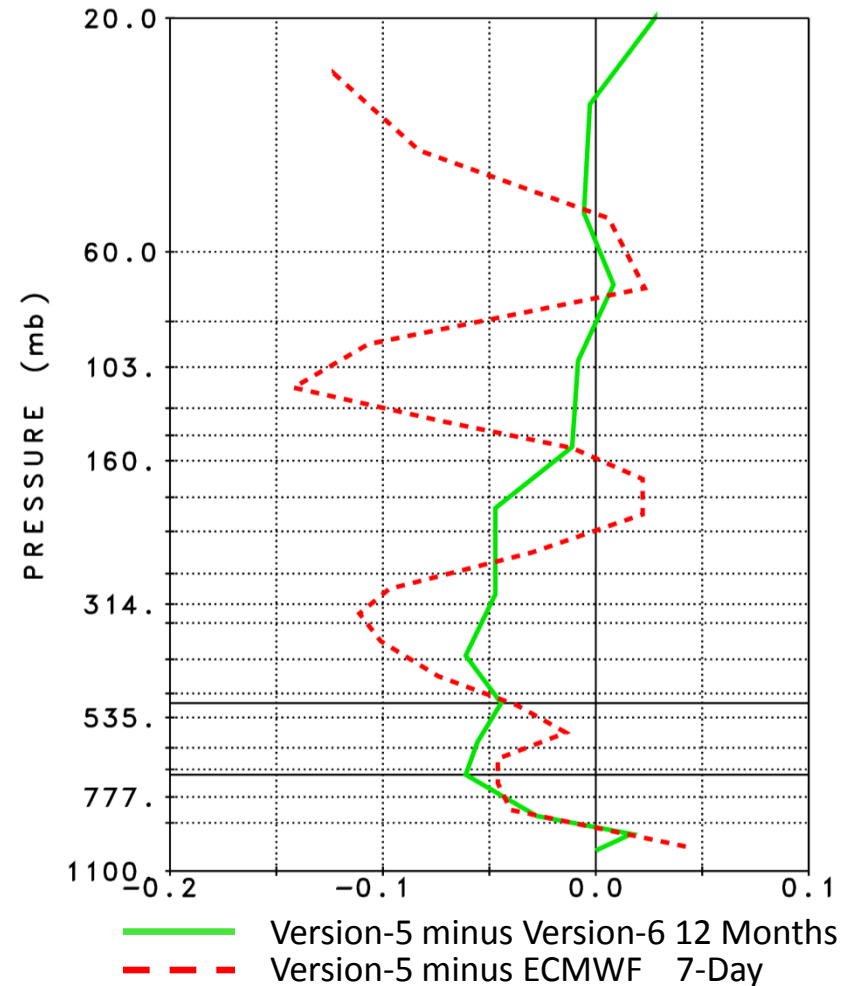
Computed V5 and V5.9.12 product trends can be misleading because whole annual cycle is not captured

The trend difference V5 minus V5.9.12 is much more significant

Global Temperature Trends K/Yr 12 Monthly, January 2003 through October 2011



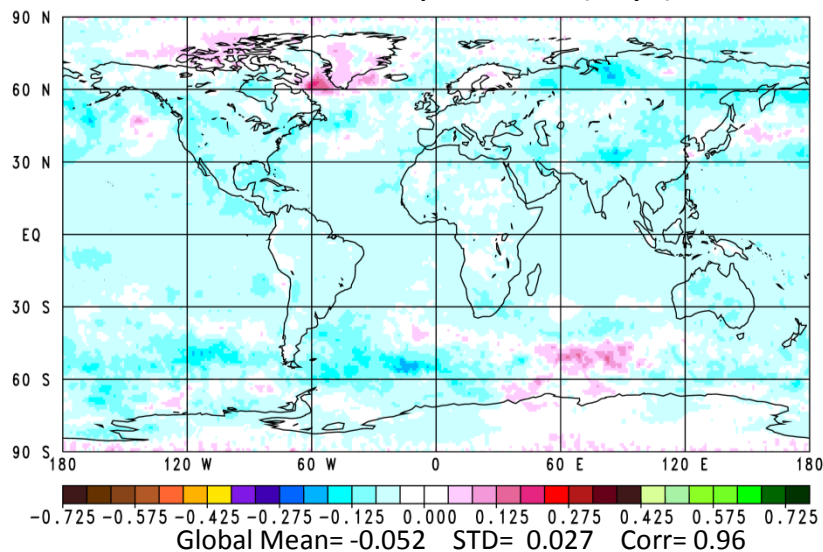
Global Temperature Trends K/Yr



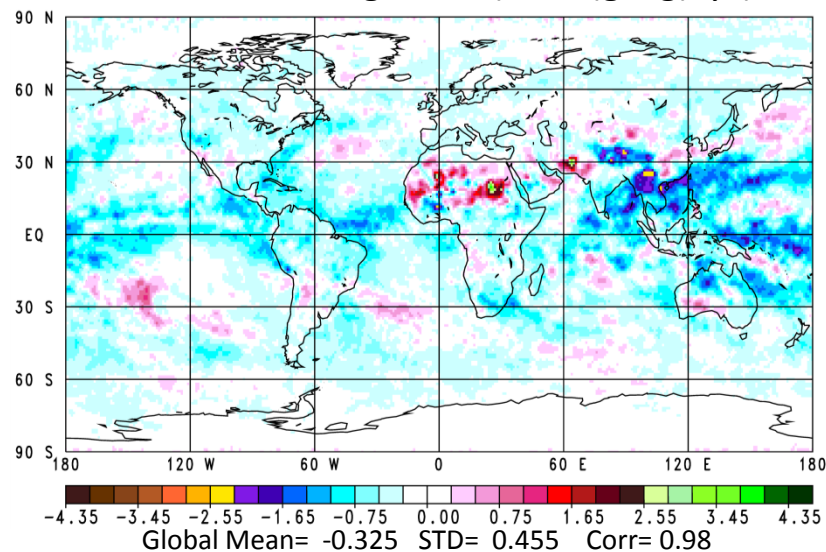
Version-6 should minimize spurious negative T(p)
trend found in Version-5 beneath 200 mb

12 Month Trend Differences Version-5 minus Version-6

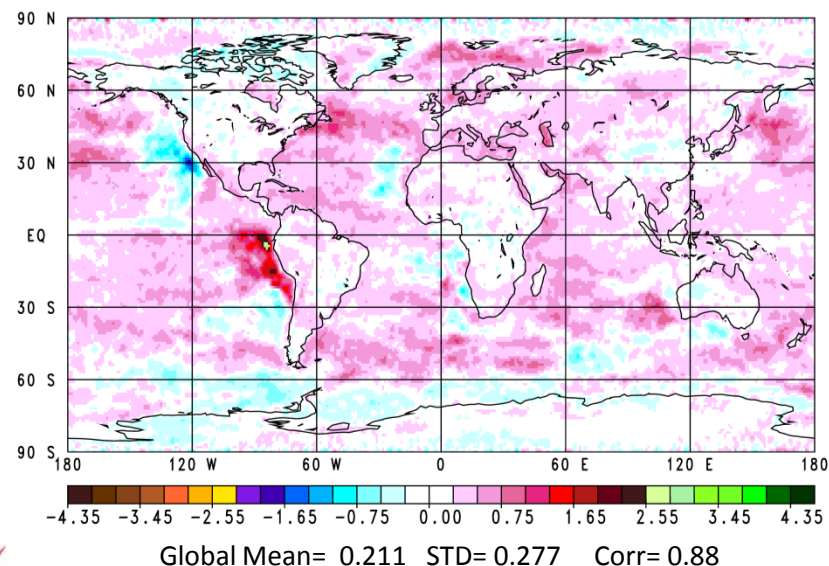
500 mb Temperature (K/yr)



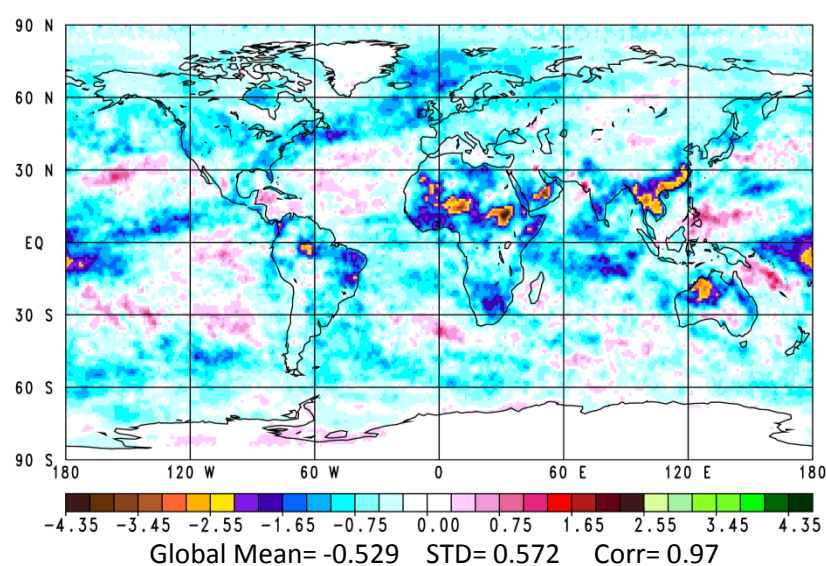
500 mb Mixing Ratio (100*(g/kg)/yr)



Cloud Fraction (%/yr)

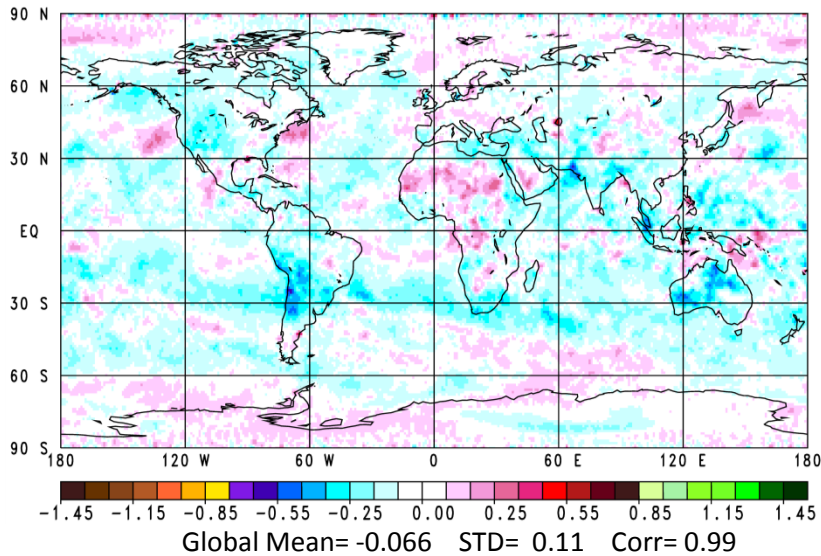


Total Precipitable Water (mm/yr)

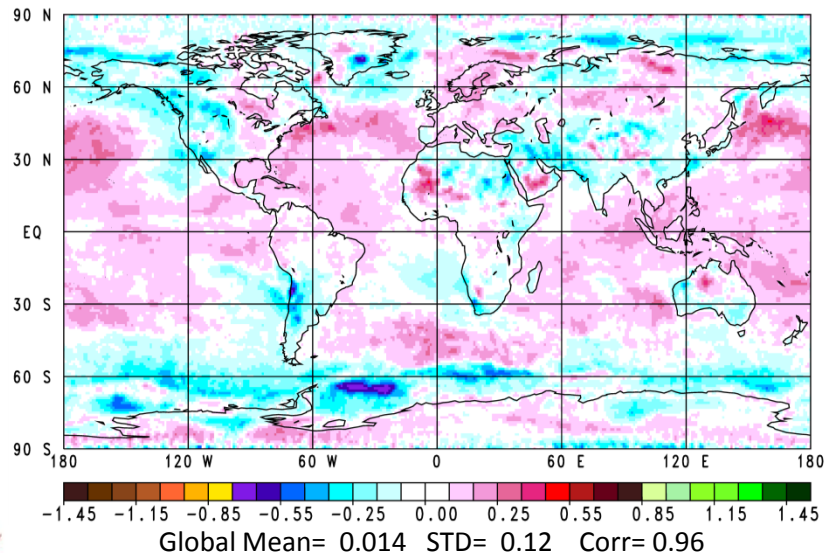


Trend Differences ($\text{W/m}^2/\text{yr}$)

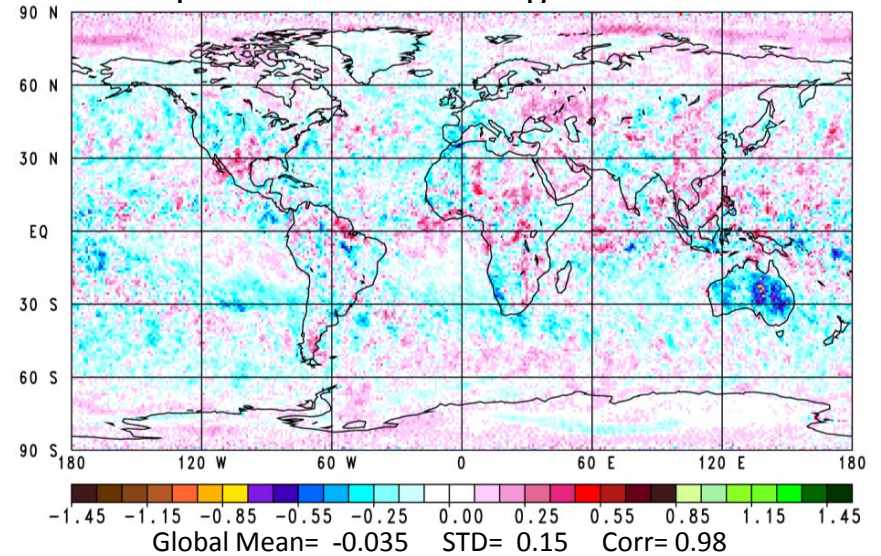
Version-5 minus Version-6 OLR
12 Months



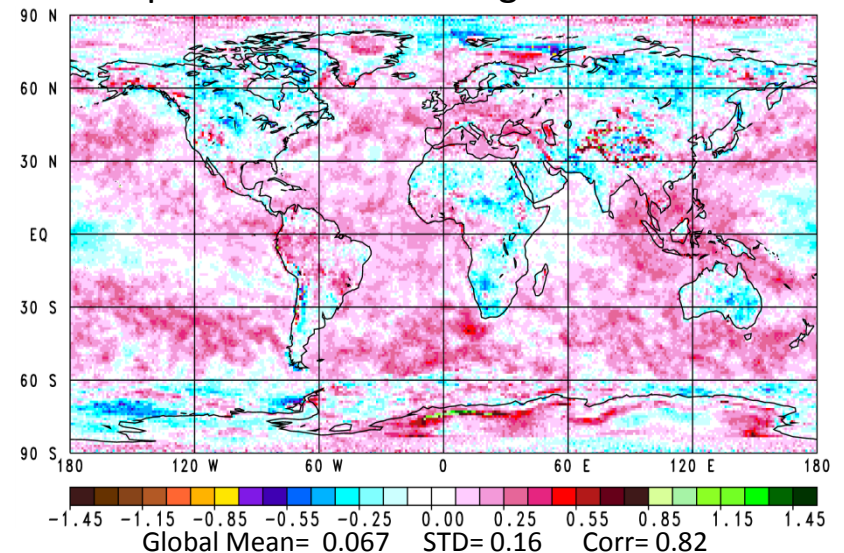
Version-5 minus Version-6 Clear Sky OLR
12 Months



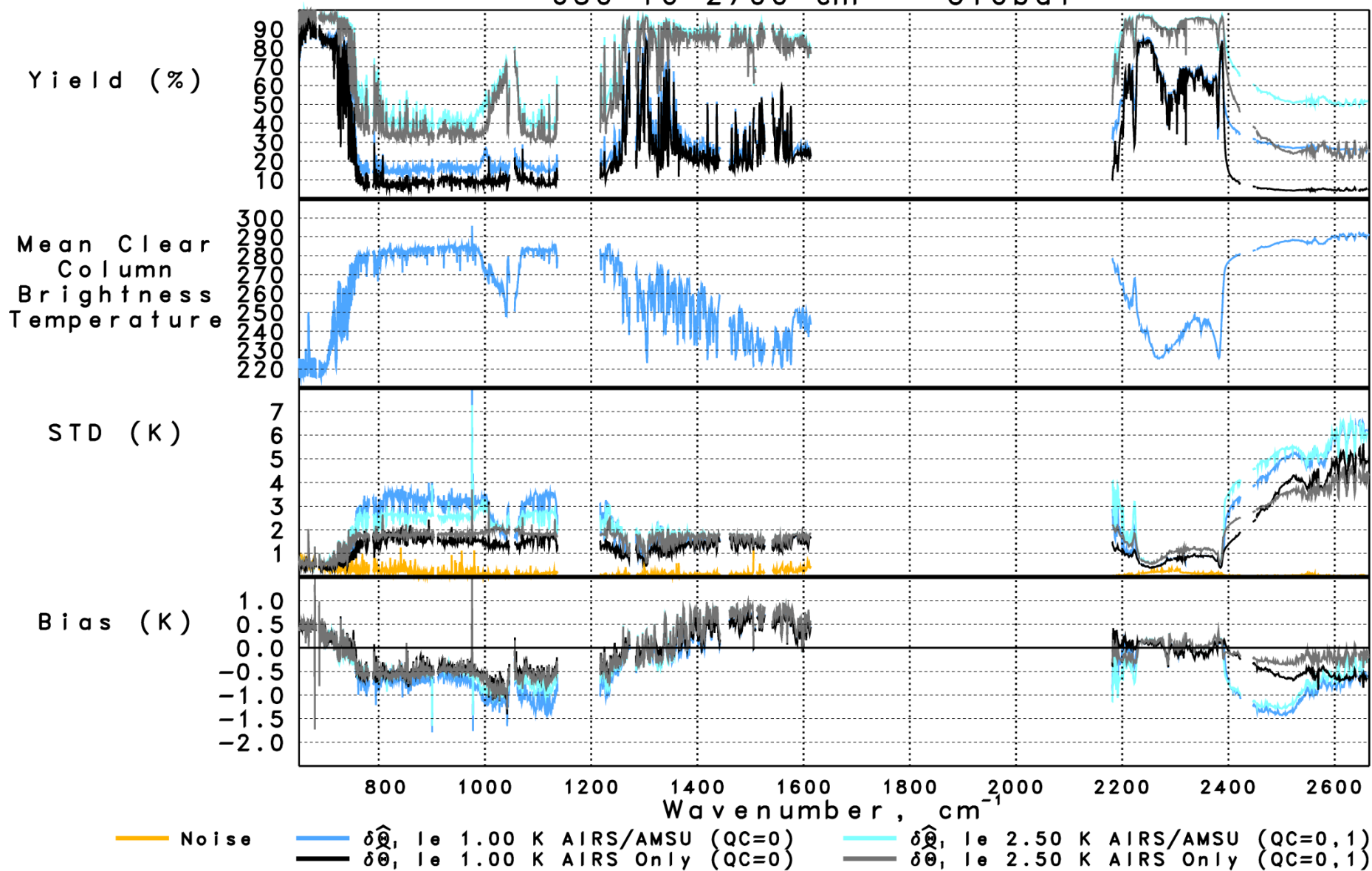
AIRS minus CERES OLR
September 2002 through June 2011



AIRS minus CERES Clear Sky OLR
September 2002 through June 2011



Quality Controlled ($\hat{\theta}_1 - \theta_{1, \text{Truth (ECMWF)}}$) Version-6.02
 7-Day Day and Night
 650 to 2700 cm^{-1} Global

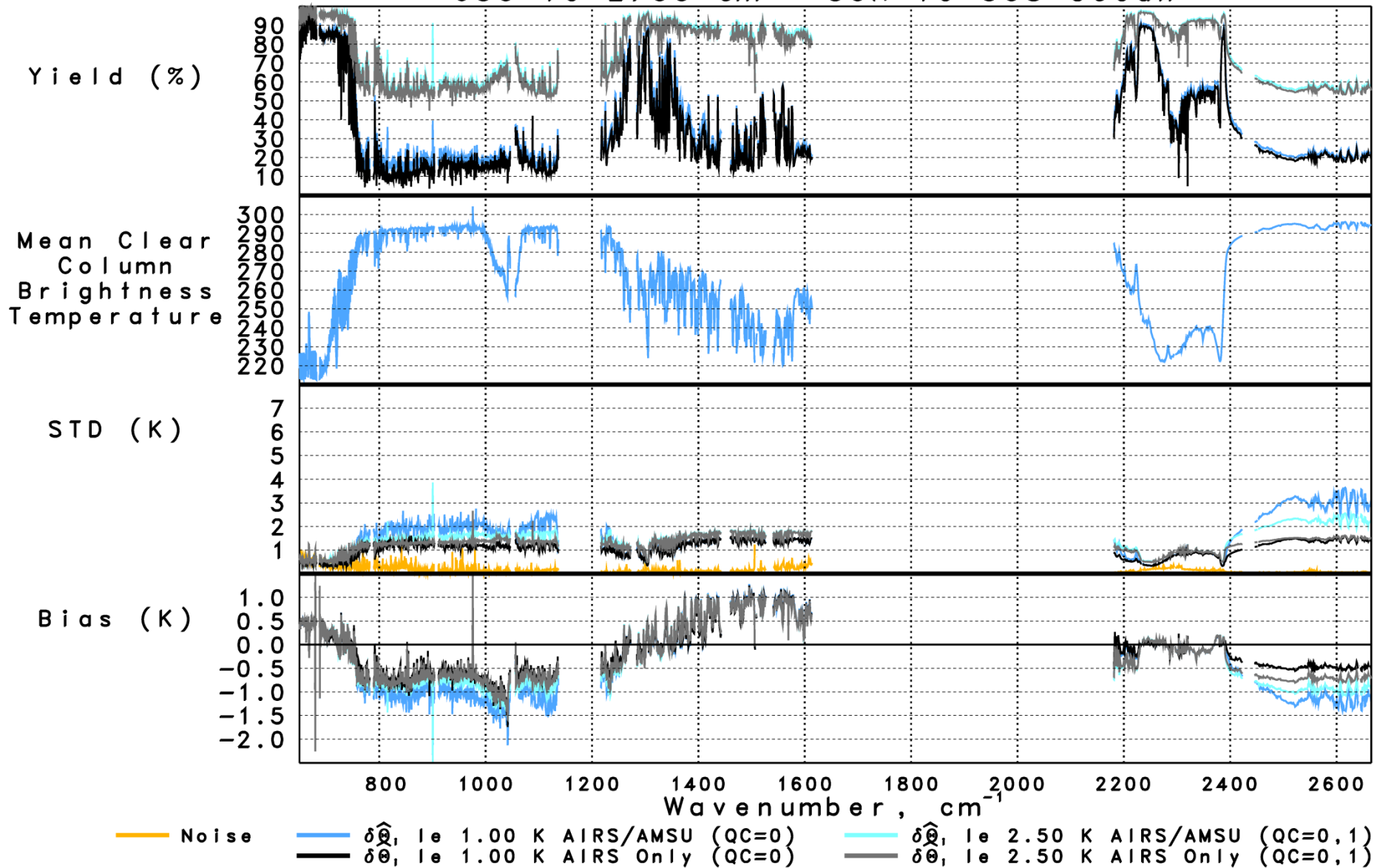


Quality Controlled ($\hat{\theta}_1 - \theta_{1, \text{Truth (ECMWF)}}$) Version-6.02

7-Day

Nighttime

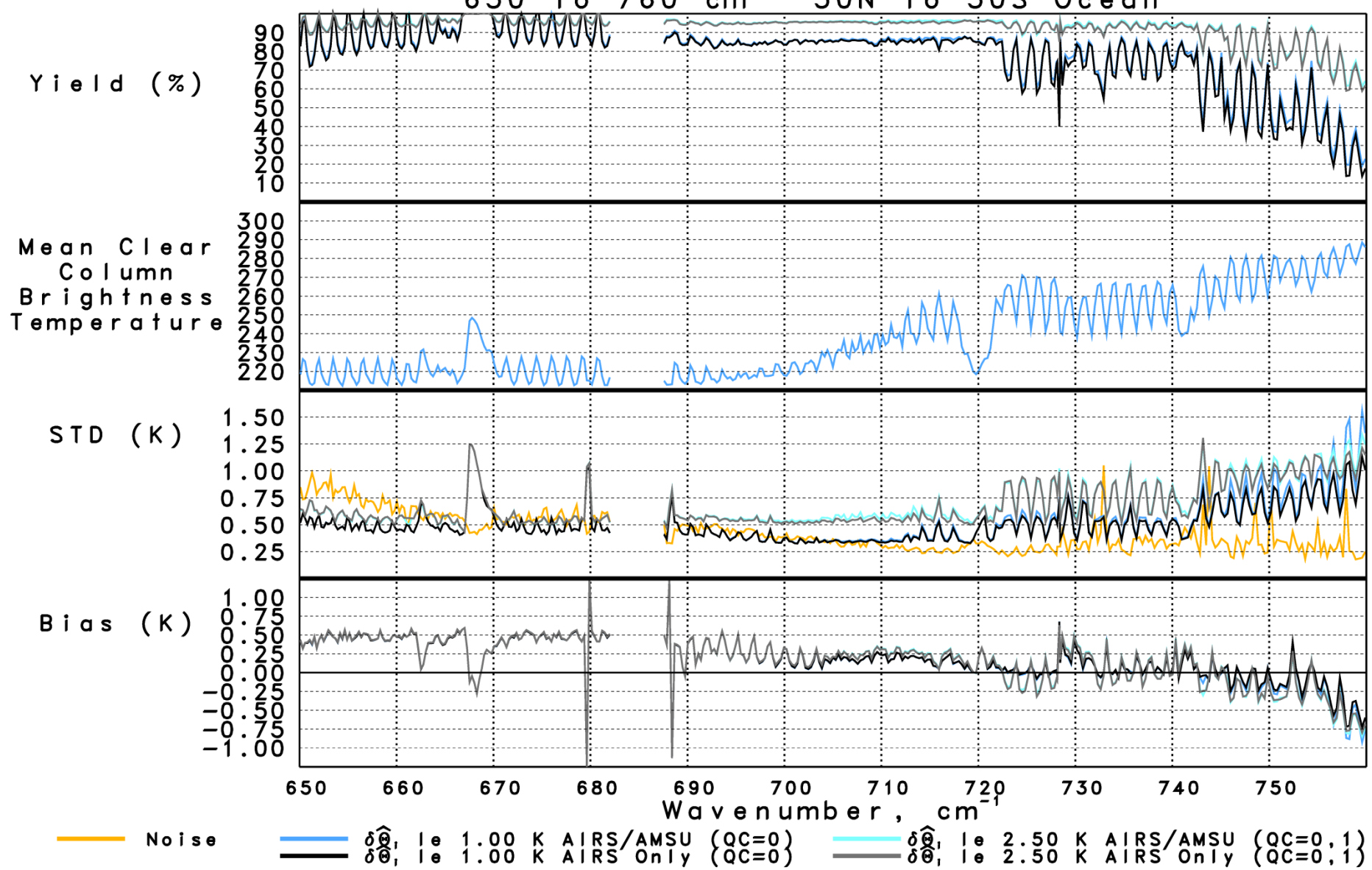
650 to 2700 cm^{-1} 50N to 50S Ocean



Quality Controlled ($\hat{\theta}_1 - \theta_{1, \text{Truth (ECMWF)}}$) Version-6.02

7-Day Nighttime

650 to 760 cm^{-1} 50N to 50S Ocean



Summary

All Version-6.02 products are significantly improved over Version-5
Level-2, Level-3

yields, RMS accuracy, biases, trends

Channel-by-channel QC for cloud cleared radiances work very well
Was not a part of Version-5

We see no shortcomings in Version-6 products that must be
changed before delivery

An analysis of trends from 12 months of Version-6, Version-6 AO
should still be done

We do not expect much difference from Version-5.9.12

We expect that Version-6 AO will also perform well

We will also look at trends of spectral OLR